18. This approach is not capable of dealing with all the issues either. The intensity-of-use technique is unable to isolate the effects of changes in the quality of a material on its demand (for example the development of new alloys), nor is it possible to distinguish between the effects of intra-material substitution and the effects of material saving technologies (which would require using input-output tables that are not available for a large number of industries and countries). However, the intensity-of-use technique can be used as a complement to other methodologies, so as to obtain a broader perspective on the interrelationship between various factors influencing commodity-demand growth rates.

All variables in the equation are expressed in volume terms, i.e. GDP in constant prices and consumption in metric tons/cubic metres. The second term in equation (1) is simply the GDP-based intensity of use (IU), which can be rewritten as:

$$C = GDP \times IU \qquad (2)$$

Totally differentiating equation (2) and dividing through, we obtain:

$$\hat{C} = \hat{GDP} + \hat{IU} \qquad (3)$$

where $\hat{C}$ = consumption growth rate
$\hat{GDP}$ = GDP growth rate
$\hat{IU}$ = IU growth rate

17. Equation (3) simply postulates that the growth rate of commodity consumption is the sum of the growth rates of GDP and intensity of use. The actual differentiation is provided in the mathematical appendix, but we should point out here that changes in GDP per se also affect the IU term (as discussed in the appendix). Therefore, the figures presented in this paper underestimate the relative importance of the GDP variable on consumption growth rates. Using this simple formula developed by Tilton, the relative effects of the GDP variable and the intensity-of-use variable on the growth rates of commodities consumption are presented in chapter II. By extending the Tilton formula, the paper attempts to account for the effect of restructuring and provides a better estimate of the role of technological change.

By postulating

$$C = GDP \times (C\backslash MAN) \times (MAN\backslash GDP) \qquad (4)$$

and rewriting equation (4), it follows that

$$C = GDP \times IUM \times RBS \qquad (5)$$

where

IUM = intensity of use in manufacturing value-added
RBS = share of manufacturing value added in GDP

Totally differentiating (5), and multiplying,

$$\hat{C} = \hat{GDP} + \hat{IUM} + \hat{RBS} \qquad (6)$$

where

$\hat{RBS}$ = growth rate of manufacturing value added in GDP, which is used as a proxy for changes in the composition of GDP.

input-demand for metals as a dependent variable, is a linear function of prices of metals, the price of energy, the prices of substitutes, the total output variable and the stock of capital.

$$MTL = \alpha^0 + \alpha^1 O + \alpha^2 PMTL + \alpha^3 PSML + \alpha^4 PEN + \alpha^5 WGE + \alpha^6 K + \alpha^7 t$$

where MTL is the demand for metals, PMTL is the price of metals, PSML is the price of other materials (including substitute metals), PEN is the price of energy, WGE is the wage rate, K is the fixed capital input and t is the time trend picking up technical progress.

14. The advantages of this model as compared to the standard demand model are that it is fully specified, and that it takes into account the effects of the two oil price shocks. To test for the hypothesis that there was a structural change in the demand for metals during the 1970s, Choe performed a series of Chow tests to establish whether there was a significant change in the coefficients following the 1973 oil crisis. The same tests were used to establish the significance of the variables added to this model. Choe concludes that the hypothesis of no structural change in the demand relationship cannot be rejected.

15. However, the approach used by Choe still suffers from the above-mentioned limitation regarding the effects of prices and the exact role of technological change. He finds that technological change positively affected the consumption of *aluminium* and, when a weighted average is taken for the six metals under study (*aluminium*, copper, lead, nickel, tin, zinc), he obtains a positive coefficient for the time trend for metals as a group. This is due to the large weight of *aluminium* in total non-ferrous metal consumption. Although the positive coefficient of the time trend in the equation for *aluminium* can be explained by the increasing substitution of *aluminium* for other metals in a large number of end-uses, this model is not suitable for measuring the impact of technological progress on the demand for *aluminium*. Thus, in Choe's model, the time trend picks up a multitude of factors which have influenced metals demand (among others, the effect of restructuring) and so, for the purposes of this study, this model could not have been used as a reliable estimator of the effects of technological progress and other factors which shape the long-run demand trends.

B. <u>Extending the Tilton model</u>

16. Since the above-mentioned approaches had not been designed to deal with some of the salient long-run features of the demand for raw materials, a model for analysing the dematerialization hypothesis was needed. This has led to the emergence of the intensity-of-use technique (IUT) in order to measure the relative impact of GDP, technology and restructuring on the long-run behaviour of commodity demand. The technique was originally developed by Tilton (op. cit.), and was extensively used to analyse commodity consumption trends. The technique is developed from a simple identity, where:

$$C = GDP \times (C/GDP) \qquad (1)$$

11. A second line of thought has tried to explain the declining rates of growth of raw material consumption by a life-cycle hypothesis. This followed the original work by J. Dean, 9\ which was later developed by G.W. Bain. 10\ The theory's applicability is limited to the study of the behaviour of the demand for metals and minerals, and it does not explicitly explain the declining intensity of use of agricultural raw materials. Although it could be extended to deal with this group of commodities, it would not be useful for the purposes of estimating the effects of technological progress on the demand for raw materials. Although the life-cycle hypothesis can be used to gain some interesting insights regarding the consumption trends of some metals and minerals, it is too vague for the purposes of drawing conclusions about the relative contributions of structural as opposed to cyclical factors affecting commodity demand. The life-cycle hypothesis postulates that metals go through a phase of youth, maturity, old age and decline. The length of each phase is determined by technological advances occurring in the production process, by inter-material competition and by the relative prices of metals. However, the set of propositions advanced by this approach is not testable since no formal model has been presented in support of the theory. Thus, in some end-uses, a metal may be in its first or second stage, whereas in other end-uses it may have reached the third or fourth stage. Also, in some geographical regions, a material may be in its mature stage while in another region it might be in its infancy. Moreover, the theory is too general, failing to account for cases where the metal does not exhibit the set pattern, for example owing to a technological breakthrough in the production process or because of the development of a substitute. It cannot be ruled out that some natural material, which seem to have entered the phase of decline according to the life-cycle hypothesis, get a new lease on life because of changing consumer tastes, technological developments or changes in energy prices (cotton, natural rubber and wood are cases in point).

12. An econometric approach for explaining lower raw-material demand growth rates consists of setting up a demand equation with the following explanatory variables: the price vector of the commodities under study; the price vector of close substitutes; the GDP variable which picks up the level of economic activity; and a "time" variable which is interpreted as the effect of technological change on the demand for raw materials. This approach has been primarily developed for analysing short-run demand trends. The reason behind the inadequacy of such models to deal with long-run trends could be that prices do not affect commodity demand in a continuous way or that they have a strong indirect effect on demand. The former is supported by empirical evidence suggesting that prices influence firm decision to substitute for another material only at some threshold level which implies a kinked demand function. The indirect effect operates through the incentive to firms to intensify research into material saving technologies or the development of substitutes following an increase in the price of raw materials. This type of firm behaviour is supported by various case studies. 11\

13. Another problem with standard demand equations, as Boum-Jong Choe 12\ points out in his study on metals demand, is that the orthodox demand model is unspecified if commodities and energy are complements in production. Therefore, he estimates an extended metals demand equation derived from the firm's aggregate cost function. The estimated demand equation, with the

I. EXTENDING THE INTENSITY-OF-USE TECHNIQUE

A. Review of the existing literature

8. The literature on commodity demand can be divided into two groups of models. The first group tries to identify the long run determinants of consumption growth and focuses on structural shifts in the economy as it moves along a development path. The second group of models tries to identify medium-term factors which affect raw-materials demand. These models use an econometric approach, where the prominent variable affecting the result is the price vector of inputs used in the production of a final good.

Figure 1

9. The explanation for the lower growth rates of raw-materials demand suggested by Malenbaum 7\ relates the evolution of the intensity of use to the level of per capita income in the economy. This is known as the "intensity-of-use hypothesis," where the intensity of use is an inverted U-shaped curve in the intensity-of-use and per capita income space (see fig. 1).

10. However, Malenbaum's hypothesis has drawn some criticism from academic circles. First, the relationship between the growth rates of the per capita income variable and the evolution of intensity of use is not formally modelled; thus it is impossible to estimate at what level of per capita income the intensity of use should start declining. Secondly, Malenbaum did not provide a robust theory to explain the economic channels through which per capita incomes affect the growth rates of intensity of use. The suggestion that per capita income can be used, inter alia, as a proxy for intersectoral restructuring (i.e. the service sector expands at the expense of the manufacturing sector) which is supposed to cause the decline in the intensity-of-use growth in DMECs was found to be questionable. Moreover, the recent work undertaken by Humphreya 8\ further questions the validity of Malenbaum's hypothesis. Humphreya has studied the evolution of the intensity-of-use index of non-ferrous metals for the period 1900-1985 in the industrialized countries and has found no close correlation between the evolution of the intensity of use and the growth rates of per capita income.

for this phenomenon. However, as more recent works have suggested (not only in the field of commodity-demand trends but also in other fields such as studies on labour-productivity growth in OECD countries), the period 1950-1973 might have been atypical of the longer term historical trends, in which case the commodity growth rates we have been observing over the last 25 years should not be interpreted as being exceptionally low.

4. The paper is divided into four chapters. Chapter I contains a short review of the literature and outlines the work that has been done so far. It presents some of the main findings and explanations advanced by various authors for the declining growth rates of materials demand.

5. Chapter II presents estimates on consumption trends, GDP growth rates and the evolution of the intensity of use for 20 industrial materials for the period 1965-1988 6/ and assesses the relative impact of each variable on the demand growth rates of raw materials. In order to isolate the effect of structural and technological change, the intensity-of-use variable is then divided into the intensity of use in manufacturing value-added and the share of manufacturing value-added in GDP. For DMECs, the chapter takes a closer look at the process of intra-sectoral restructuring in the manufacturing sector by selecting branches that use raw materials intensively. The evolution of their share in GDP is estimated in order to assess the importance of intra-sectoral restructuring on commodity demand during the 1970s and 1980s. On the basis of these results, an evaluation is given of the hypothesis of "decoupling" of GDP growth and the demand for commodities.

6. Chapter III assesses the importance of country groups relative to total demand for raw materials. Taking various assumptions about GDP growth rates and the rate of technological progress in DCs, the chapter looks at the potential of DCs to become important final consumers of raw materials. A hypothetical evolution of commodities-demand trends extrapolated from trends prevailing in the 1960s and early 1970s is used to evaluate the effects of the break in the growth rates of demand that occurred after the oil price hikes. In the same context, the potential for demand to pick up in the future is estimated.

7. Chapter IV draws the general conclusions which emerge from the analysis.

Summary

1. The last two decades have witnessed a sharp decline of growth rates in consumption of non-fuel raw materials. This implies a declining rate of growth of receipts stemming from the exports of this group of goods. Since a large number of developing countries earn a considerable proportion of their foreign exchange from the export of raw materials, the change in the evolution of raw materials consumption is of particular concern to them. Thus, in the late 1980s, among 146 developing countries and territories, 81 relied on non-fuel commodities for at least 50 per cent of their export earnings; of these, 39 were least developed countries for most of which commodity exports represent 80 per cent of export earnings. 1/ The issue for developing countries is whether the current slack commodity demand is a consequence of the economic slow-down, which could be reversed in future, or whether it is a reflection of structural change and technological innovation, which will persist or even intensify. Although the question of raw-material consumption trends has been studied over a number of years, the question of the relative impact of various factors affecting the final consumption of raw materials remains of great interest, in particular for raw-material exporting countries. In particular, the issue of the possible "decoupling" of GDP growth from raw-material demand growth is still of major concern to developing countries.

2. It is the purpose of this paper to examine consumption 2/ trends of non-fuel, non-food raw materials based on an extended coverage. 3/ The paper analyses the relative importance of technological advances as compared with other economic forces that have shaped the observed behaviour in raw materials demand during the 1970s and 1980s, with a special emphasis on the post-1973 period. Estimates of the relative contributions of lower rates of GDP growth, cross-sectoral and intra-sectoral restructuring, as well as technological change, to the declining rates of growth of raw materials demand are presented. As a point of departure, the analysis is based on the intensity-of-use technique (IUT) as developed by Tilton, 4/ which is a growth accounting formula and not an econometric model. It is then applied to several country groups (developed market economy countries (DMECs), developing countries (DCs), developing Asia and America). The study assesses the trends in the intensity of use (intensity of use is defined as a physical amount of consumption of a commodity per unit of GDP at constant prices) in each country and commodity group. The methodology is then broadened in order to account for changes in intensity of use due to technological progress (which includes both the introduction of new production technologies and intra-material substitution) and those owing to the process of economic restructuring. Previous work by the UNCTAD secretariat in this domain had focused on the examination of technological progress as reflected in the intensity-of-use trends, and its impact on commodity consumption growth. This report, which builds on the previous findings of the secretariat, 5/ assesses the relative contribution of intensity of use and GDP growth on commodity demand growth rates.

3. A large part of the discussion on commodity consumption trends might be misleading as a result of the choice of periods studied in the literature. Namely, most studies, including this one, tend to compare the periods of the 1950s and 1960s to the period of the 1970s and 1980s. More often than not, decline in their growth rates and various explanations are advanced to account the general conclusion seems to be that natural materials have suffered a

Preface

This report was prepared pursuant to resolution 33 (VIII) of the Committee on Transfer of Technology, which recommended that the secretariat continue to give attention to the impact of micro-electronics and new materials on trade and development opportunities of developing countries. The report examines the relative contribution of continuing technological advances on commodity consumption.

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Note

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Distr.
GENERAL

UNCTAD/ITD/TEC/14
13 April 1994

ENGLISH ONLY

UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT

TECHNOLOGY AND RAW MATERIALS DEMAND

94-51540 (E)